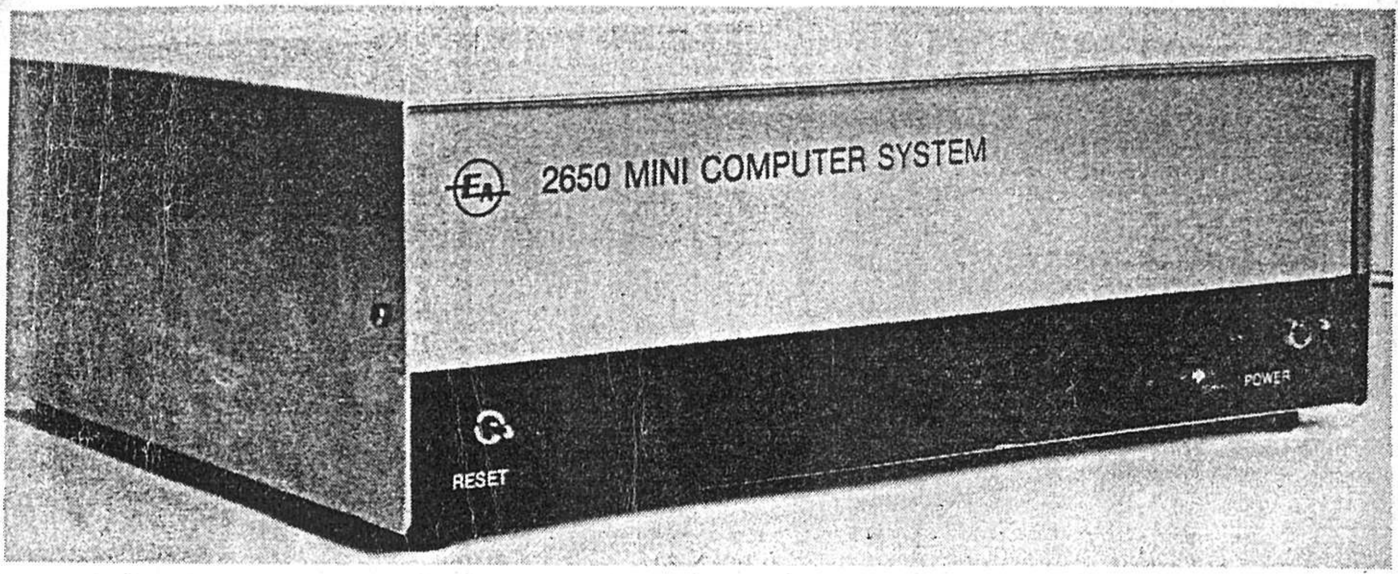


Uses latest 4K-bit RAM chips:

New, expandable 2650 mini system

The Signetics 2650 microprocessor has become quite popular among computer hobby enthusiasts, spurred on by our "baby" 2650 system described in the March 1977 issue. This and the recent release of 1024 x 4 bit RAMs has prompted us to redesign the circuit, with this article and the unit described herein as the result.

by DAVID EDWARDS

Our previous approach was to present a design for a printed circuit board unit only, which reduced costs to a minimum. With this project however, we are also describing a case and power supply, so that the unit becomes a complete stand-alone mini computer. Of course, if desired the PCB can be used by itself, as before.

We estimate that the complete unit will retail for around $115.00, which is very reasonable considering the features of the unit.

What are the features of the unit? Well, it has a debug and monitor program resident in a 1k ROM, a standard 20mA asynchronous communication link, a minimum of 1k of RAM, full memory decoding, provision for memory and I/O expansion, and an on-board power supply.

All this is contained on a single-sided PCB, measuring only 218 x 81mm. The only other components required are a reset switch and a power transformer and associated hardware.

At the heart of the circuit is the 2650 MPU chip itself. This is an 8-bit device, with an instruction set of 75 instructions, and having eight different addressing modes. It is fabricated using low threshold ion implantation, and is an N-channel silicon gate device operating from a single 5V supply, with all inputs and outputs TTL compatible.

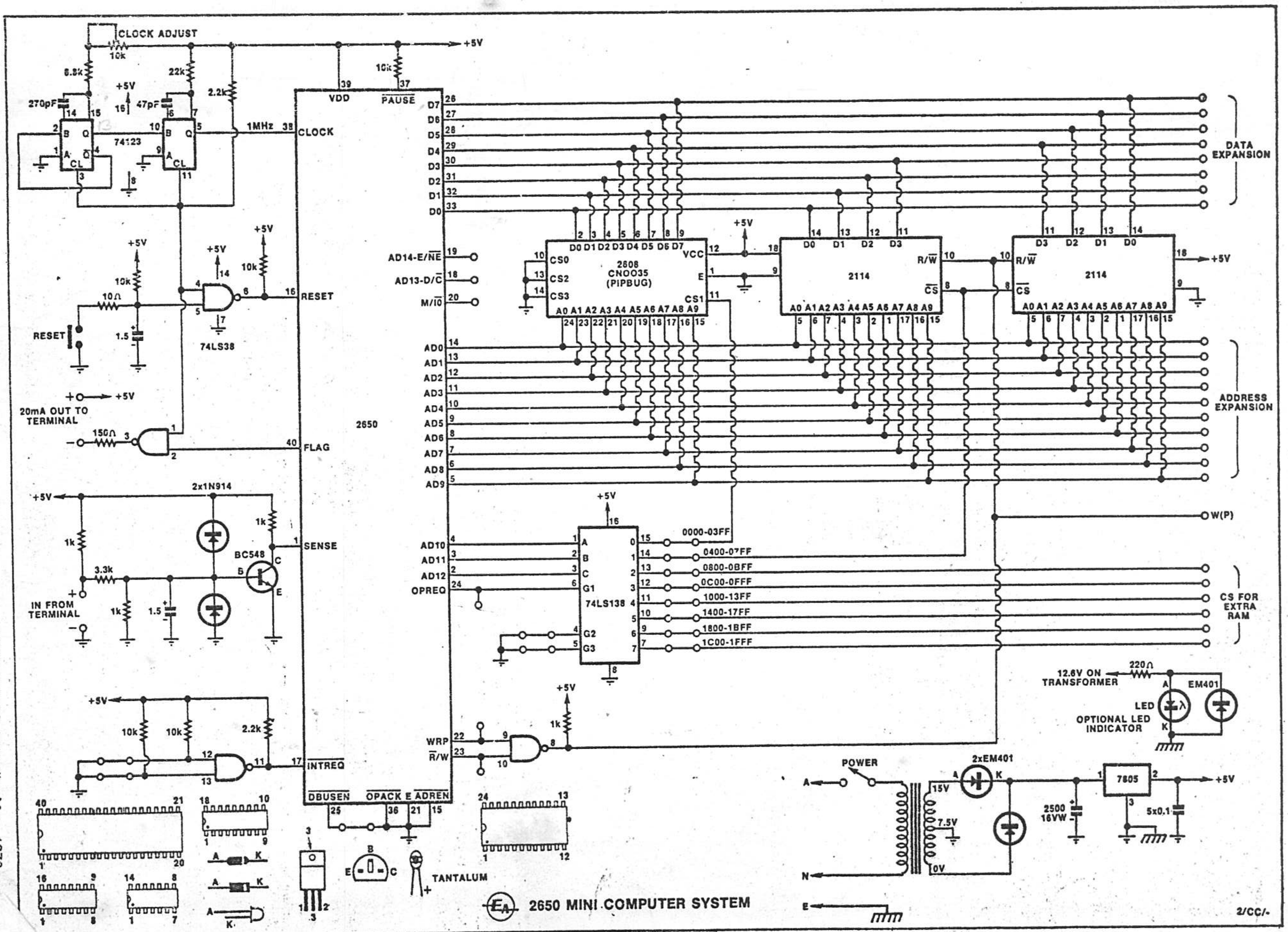
A 74123 dual monostable is used to generate the single phase 1MHz clock required. A trimpot is used to set the correct operating frequency, which can be adjusted without the use of special test equipment.

The debug/monitor program, code named "Pipbug", is resident in a 2608 ROM. Pipbug recognises seven basic commands, each of which consists of an alphabetic character, any required numerical parameters, and a terminating return. The parameters are given as hexadecimal characters, with leading zeros unnecessary.

The seven commands and their functions are as follows:

A — See and alter memory;
B — Set breakpoint (2 permitted);
C — Clear breakpoint;
D — Dump memory to tape;
G — Go to address, run;
L —Load memory from tape;
S — See and alter registers.

Only two of a maximum of eight RAM chips are shown in the circuit diagram at right. The rest are wired similarly.



2650 MINI COMPUTER SYSTEM

List of component parts

3 — 16 pin DIL

SEMICONDUCTORS
1 2650 MPU chip
1 2608 CN0035 ROM (Pipbug)
2 2114 1024 x 4 static RAMs
1 74LS38 quad open collector gate
1 74123 dual Schmitt trigger
1 74LS138 decoder
1 7805, LM340T-5.0 5V regulator
1 BC548 or similar NPN transistor
2 1N914 or similar silicon diodes
2 EM401 or similar silicon diodes
CAPACITORS
1 2500uF 16VW PCB mounting electrolytic
2 1.5uF tantalum electrolytics
5 0.1uF polyester
1 270pF polystyrene
1 47pF polystyrene
RESISTORS (all ¼W)
1 10k trimpot (5mm lead spacing)
1 22k, 5 10k, 1 6.8k, 1 3.3k, 2 2.2k, 4 1k, 1 150 ohm, 1 10 ohm
MISCELLANEOUS
1 40 pin DIL socket
1 24 pin DIL socket
2 18 pin DIL sockets
3 PCB standoffs (9.5mm)
1 SPDT miniature toggle switch
1 SP miniature momentary contact switch
1 transformer, 240V to 15VCT @ 1A. DSE 2155, A&R 2155 or similar
1 PCB, coded 78up5, 218 x 81mm
1 case, 284 x 93mm (see text)
1 output connector (see text)
4 rubber feet
1 mains cord, mains plug, grommet, cord clamp and terminal block
2 aluminium brackets (see text)
Machine screws and nuts, PCB pins, solder, tinned copper wire, hookup wire, rainbow cable

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may generally be used provided they are physically compatible.

The D command may be used to dump out onto paper or magnetic tape any desired range of memory locations, with leader, checksum and trailer to facilitate reloading. Both the A and S commands may be auto-incremented, by terminating with a line feed instead of a carriage return.

Pipbug is explained further in Signetics Application Memo SS50, which you should receive with the 2608 ROM. It also includes a listing of Pipbug, which among other things lets you make use of some of its utility subroutines such as the serial input and output routines "CHIN" and "COUT".

Only two ICs are required to implement the basic 1k of RAM provided, thanks to the new 2114 memory devices. These are 4096-bit static memories, organised as 1024 4-bit words. Access time is 650ns or better, and all inputs and outputs are TTL compatible. At the time of writing, only devices made by Synertek are available, and these are coded SY2114.

We understand that in the near future similar devices will be available from National Semiconductor (coded MM2114) and Signetics (coded 2614). At present, the Synertek devices are available from Radio Despatch Service Pty Ltd, of 869 Gearge Street, NSW 2000, and also from Dick Smith Electronics stores and dealers.

Memory address block decoding is performed by the 74LS138 device. The A, B and C inputs, operating on address lines AD10, AD11 and AD12 produce output signals which effectively divide the memory space into eight 1k blocks, each of which is uniquely decoded within the 2650's memory address "pages" of 8k.

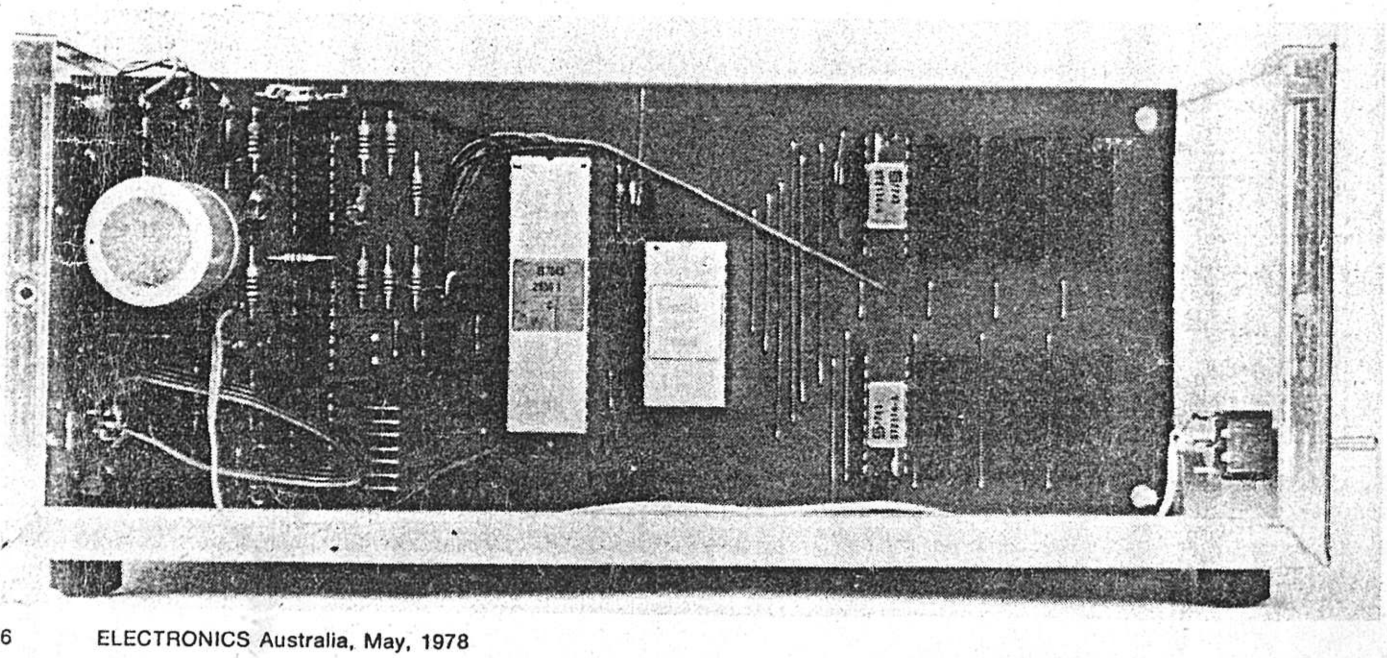
The first 1k block, from 0000 to 03FF, is assigned to the ROM, with the next block, 0400 to 07FF, assigned to the first 1k of RAM. The first 63 locations of this block are used by Pipbug as temporary storage locations, so that user memory commences at 0440.

A 74LS 38 quad open collector gate is used to perform the remaining housekeeping functions. One element is used to combine the R-bar/W and WRP signals, to form the W-bar (P) signal, which is then used to drive the R/W-bar lines of the RAMs.

A second element is used to buffer and invert the signal from the reset switch, allowing a cheap and readily available normally-open type switch to be used.

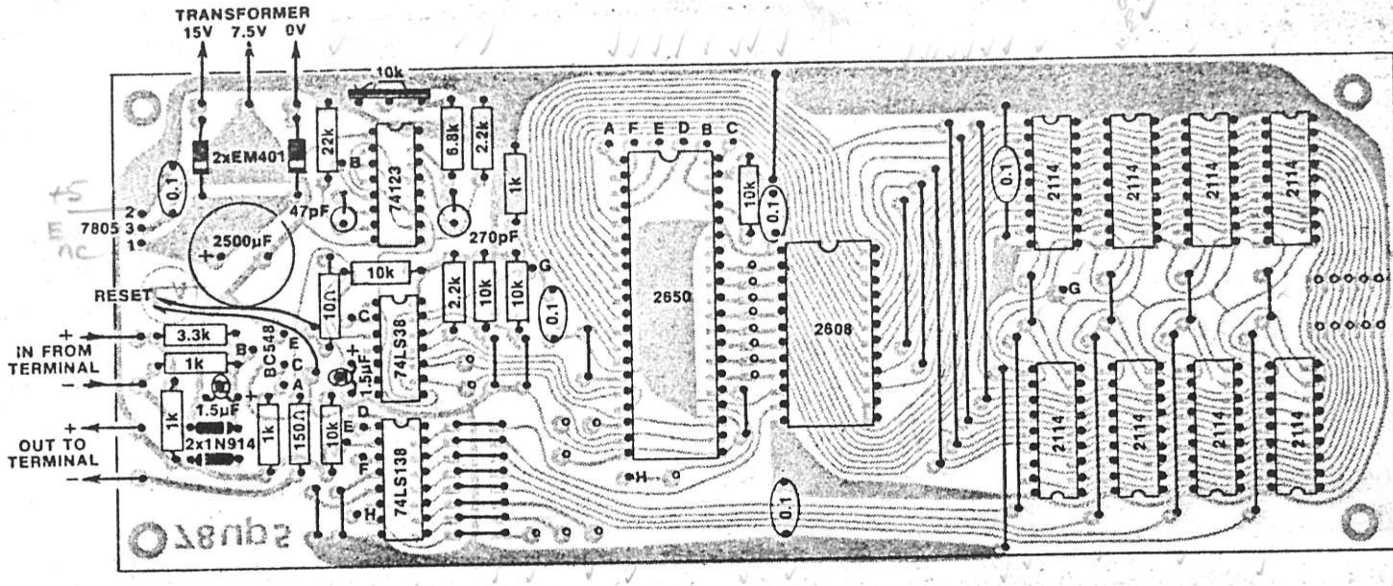
The third element is used as a 20mA current sink for the teleprinter (TTY) output signal. It was for this reason that an open collector type gate was used, necessitating the three pullup resistors on the other element outputs. The current level is set by the 150 ohm resistor, and is sufficient to operate the current loop input of an ASCII TTY or video data terminal.

The remaining gate element is not strictly required, but since it was available, we have used it to provide



This close-up photograph of the board should aid in placing the components on the PCB.

5-8✓   22.2 [illegible] Chd INQ[illegible] ✓   A✓ B✓ C✓ D✓ E✓ F✓ G✓ H✓



A B C D E F G H

two buffered interrupt request inputs.

The TTY input circuitry uses a single NPN transistor, along with a few passive components to provide a level translation from the 20mA circuit to the TTL-compatible sense input. The passive components form a filter to mitigate the effects of induced hum and switch bounce, if present.

The power supply circuit is very simple, requiring only two diodes, one electrolytic capacitor and a three terminal regulator, apart from the mains transformer. Five 0.1uF capacitors are distributed about the circuit, to minimise noise and spikes on the supply lines.

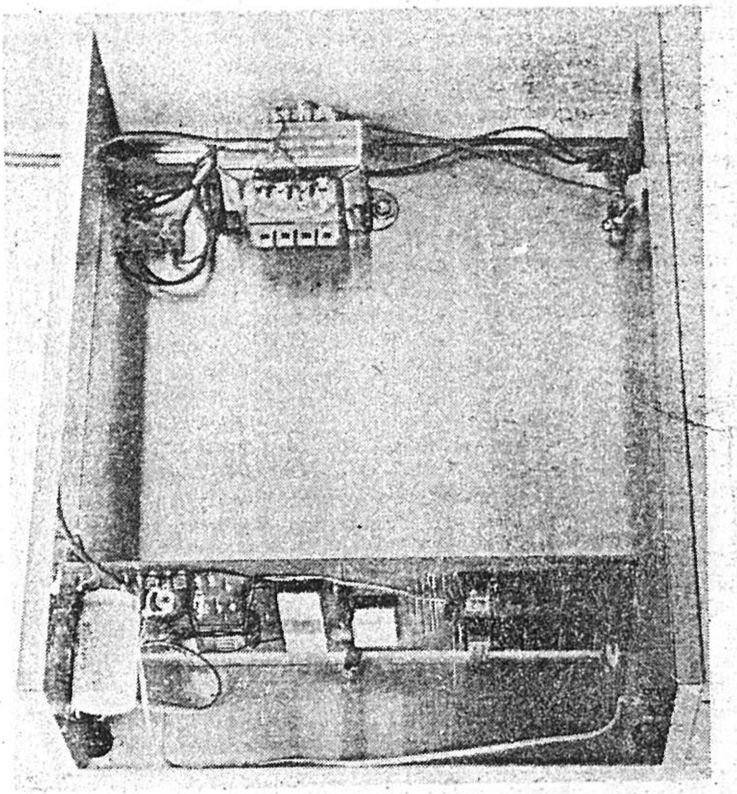
All of the previously mentioned circuitry is built up on a single printed circuit board, coded 77up5. In order to contain costs, we did not use a double sided board, so that a number of links are required. Most of these are normal uninsulated links, although there are eight insulated links which wander across the board.

Provision has been made on the board for up to four pairs of 2114 RAM chips, giving a total on-board capacity of 4k bytes of RAM in addition to the 1k byte Pipbug ROM. Note, however that only one pair of 2114's is required for operation; the other three pairs are optional, to allow you to expand the system as required.

Four pairs of 2114s represent the maximum number which can be connected to the 2650 without overloading the address and data outputs. For further memory expansion, buffering will be required.

As you can see from the photographs, the board dimensions are such that in the case we have used it can be stood on edge from front to back. This is an aluminium case of similar dimensions to that used for the Mini Scamp microprocessor design, and also the Minibrute power supply. The prototype was obtained from Dick Smith Electronics Pty Ltd.

Use the overlay diagram at the top of the page to guide you in placing components onto the PCB. Eight insulated links are required, joining the corresponding letters.



You can see in the photograph at right how much room is left in the case for expansion purposes.

The method of mounting used allows room for at least two similar sized boards in the case as well, so that mechanically, future expansion is quite easy. It also means that both sides of the board are accessible at once, so that servicing and addition of extra parts is quite simple.

The board is supported on two brackets, which we fashioned from scrap aluninium. The large bracket at the rear holds the board near the rear panel, so that the regulator can use the panel as a heatsink. The front of the board is supported by a single bracket fastened to the floor of the case. We used PCB standoffs as well, so that the PCB could be removed easily; but these may not be necessary in all cases.

We used a DIN socket as the terminal interface connector, as these are cheap and readily obtainable. It was fitted to the rear left hand corner, to minimise the length of wire needed from the PCB.

The reset switch is mounted in the front left-hand corner, with the board a little to the right of it, to allow clearance for the supply electrolytic capacitor. The transformer and associated components are mounted in the right hand side of the case, leaving the centre section clear for expansion purposes.

Commence construction by fitting all the hardware and support brackets to the case. The front panel of the prototype was made using "Scotchcal"

6-18   1-22
2-8   1-200
1-7

photosensitive aluminium, and we hope that commercial versions will be made available in due course.

We assembled the LED indicator and its support components on a small piece of tagstrip, mounted immediately below the LED BEZEL. Only one wire is required from the tagstrip to the transformer, the earth connection being made via the chassis and the tab of the power supply regulator.

Commence construction of the PCB by fitting the uninsulated links. All soldering should be done with a small pencil shaped bit, and with a minimum of solder. Be careful to avoid solder bridges.

We recommend that sockets be used for the CPU chip, the ROM chip, and the RAMs if you are at all unsure of your soldering ability with these MOS devices. Or if you wish to add extra RAM at a later date. Fit the sockets to the board at this stage, before any other components are fitted.

Now fit all the passive components, followed by the TTL ICs. Circuit board pins for the external connections should also be fitted at this point, if they are required. Mount the regulator IC, and then locate and drill the mounting hole for it in the rear panel.

The next step is to fit the eight insulated links to the board. Use rainbow cable, and join the lettered points together, routing the wires between the components, so that a neat finish is obtained. Once this has been done, mount the board in the chassis, and complete the connections to the outer connector, the reset switch and the power transformer.

Now visually check the completed board for misplaced or misoriented components, and for dry joints and solder bridges. Bolt the regulator IC to the chassis, using a little heatsink compound for improved heat transfer. Do not insulate the mounting tab from the chassis.

Now monitor the 5V rail, and switch on. If the supply does not rise immediately to 5V, switch off, and trace and rectify the fault. If all is well, adjust the clock preset so that the signal at pin 5 of the 74123 is 1MHz. If you have no means of measuring this frequency, leave this adjustment till later.

Now switch off, and insert the MPU chip, the ROM chip and one pair of RAMs. Note that the lower RAM is inverted with respect to all the other ICs. Then connect a suitable TTY or video terminal, and switch it on.

Switch the computer on, and then press the reset switch. You should be rewarded by a carriage return, a line feed and an asterisk (*). If you get something garbled, adjust the clock frequency while repeatedly pressing the reset switch till an asterisk appears. Once this happens, set the preset to the middle of the region wherein an asterisk can be obtained.

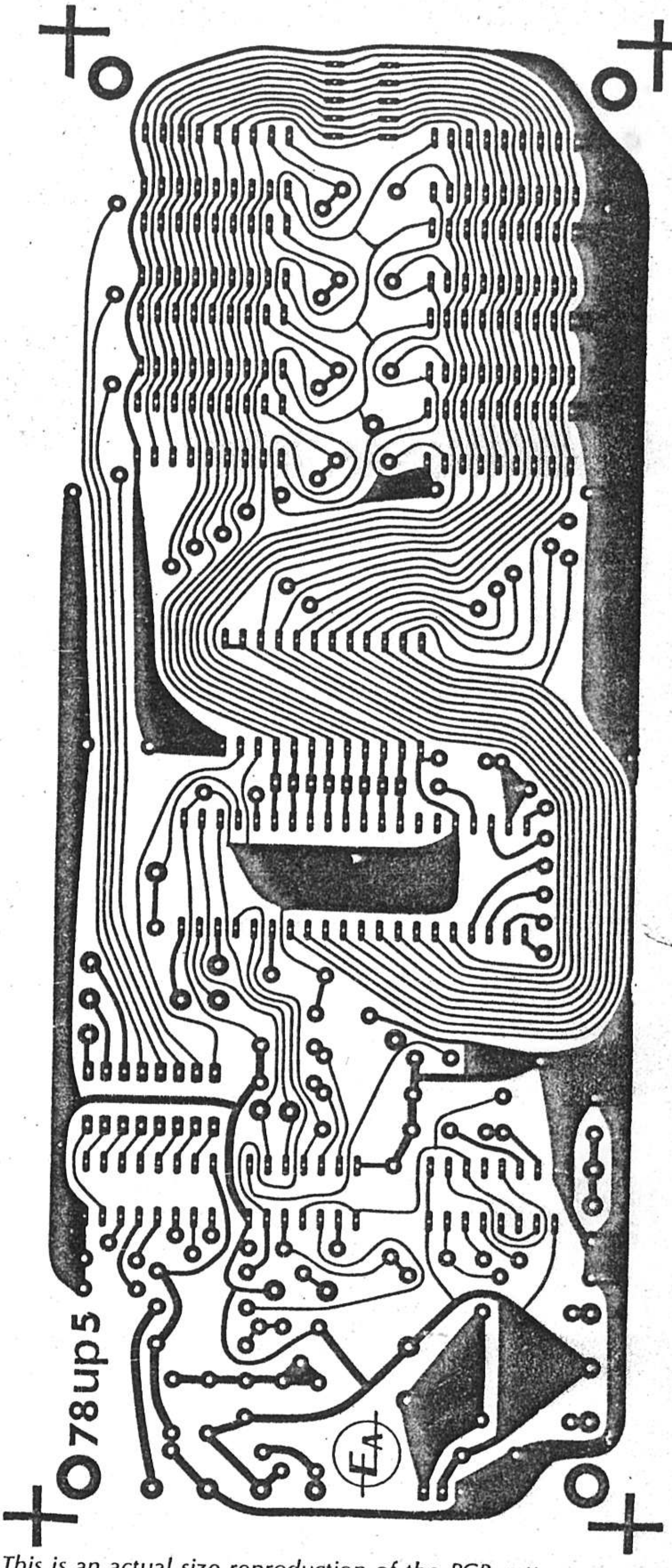
Now check out the Pipbug commands, and verify that you can load data into memory. If you have purchased the 2650 Software Package Recording offered in the April 1978 issue, then you will be able to load and run some of the smaller programs, such as "Nim" and "Number Guessing".

Note that if you can afford the full 4k of memory, you will be able to run all of the programs, with room left over for your own programs as well. And if you haven't ordered your record yet, do it now, as stocks are strictly limited.

Finally some comments concerning the expansion capabilities of the board. Most of the MPU pins required for expansion have been made available on the board. Some of them are grounded via links for normal operation, so that these links will have to be removed for expansion purposes.

Eight links have been provided at the 74LS138 outputs so that the memory configuration can be altered if required. These are arranged in a DIL pattern, so that a socket and programming plug can be used if desired.

The address and data lines, as well as the W-bar (P) signal, have been made available, so that memory expansion and input/output capabilities can be provided. It is our intention to present a second article in the near future, showing how to expand the memory up to at least 7k of RAM, and provide two non-extended I/O ports.



This is an actual size reproduction of the PCB pattern.